UNLIMITED RECYCLING OF HEAT ENERGY

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This paper gives a brief description of a device which the author believes can convert heat into electrical energy in an unlimited way.

The conversion of heat into mechanical, electrical and other forms of energy has been found to be governed by certain limitations which have been embodied in what is now known as the Second Law of Thermodynamics. It is generally held that all possible processes that convert heat to other forms of energy are subject to this law, although not all of them have yet been tested.

Over the decades, many inventions have been put forward for which it has been claimed or implied that the second law does not apply. In many cases the inventors unknowingly used the very processes on which this law is based, and so their inventions had to fail.

James Clerk Maxwell contributed to our understanding of heat, and must have reflected on the inner workings of the second law because he invented what we now call "Maxwell's demon", an imaginary entity which can sort the molecules of a gas into a high- and a low-energy collection, thereby overcoming the second law by creating a hot and cool gas body without expending a significant amount of energy.

Maxwell's solution was on the atomic and molecular scale. With the development of quantum theory in the first third of this century, scientists found that Maxwell's demon would need energy to do his sorting after all, because he needed energy (light) by which to see, and this energy expended could exceed the gains achieved. Thus it seemed that the second law had triumphed on the molecular scale as well.

In the author's view, this conclusion might have been a touch hasty. We do not have to operate on the molecular scale, the scale of one-tenth of a nanometre. If we go about 100 times higher, to a scale of about 10 nanometres (nm), the quantum restriction is 100 times weaker—and Maxwell's demon is there, waiting to be put to use.

The principles on which this proposal is based were discovered by the author in about 1960. A paper based on these was submitted to the journal *Nature* in 1972. At the same time, about 20 copies with accompanying letters were sent to a selection of national embassies. The writer believed that the proposal had a good chance of being practical, and governments should be forewarned so that the new technology could be brought into use without undue dislocation and so that existing energy technologies could be adapted. The submission was rejected, and the technology has clearly not yet come into public use.

Since 1972 there has been much progress in small-scale technology, particularly in what we call "nanotechnology". Perhaps this time, people with the necessary skills and resources will recognise the potential in this device and commit themselves to its development.

ELECTROSTATIC GENERATOR

The device works with heat energy on a scale of about 10 nm, and the "demon" is "contact potential". Metals are a class of substance in which the naturally occurring charges (electrons) that surround every atom are free to move about within the substance. This makes metals electrical conductors. Non-metals have their electrons bound to atoms or molecules, and they exhibit little or no electrical conductivity.

Although electrons may move freely within a metal, they cannot readily escape into the space around the metal. For each metal, a certain amount of energy is needed to lift the electron into the surrounding space. Different metals require different amounts of energy for this. When two different metals touch, the metal having the greater attraction for electrons will attract electrons from the other metal and become negatively charged, and the voltage associated with this charge eventually stops the flow of electrons. This voltage is known as the "contact potential" of that metal pair.

Figure 1 shows an electrostatic generator based on contact potential. Small metal balls are confined to the space between two metal plates A and B. When the balls touch plate A, they acquire one excess electron because of contact potential. When they touch plate B, they give up any excess electrons they may possess, as well as one extra electron—which leaves them electron-deficient or positively charged. If

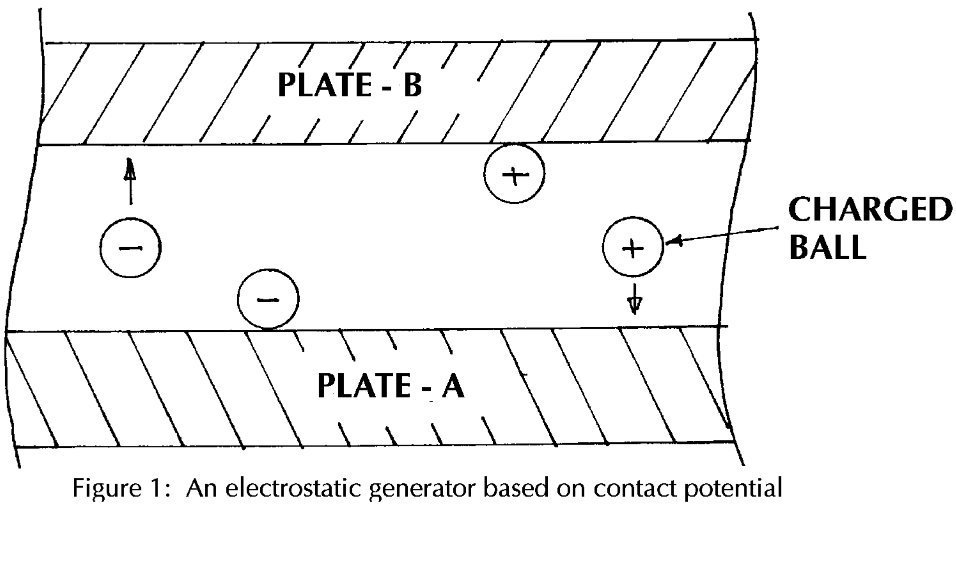

Figure 1: An electrostatic generator based on contact potential

we were to shake this device up and down, causing the balls to bounce between the plates, electrons would be transported from plate A to plate B. These electrons could be allowed to return through an external circuit and do work. We can regard this device as an electrostatic generator.

THERMAL CONVERTER

The electrostatic generator can become a thermal converter if we cause heat to do the shaking about of the balls. Heat energy is constantly trying to shake the balls. The energy available for this is proportional to the absolute temperature, *T*, and is calculated with the constant, *k* (Boltzmann's constant). When the balls are small enough, their agitation by heat energy fluctuations can make them bounce back and forth between the plates. At a diameter of 10 nm, the thermal activation of the balls is sufficient, and we have the possibility of a thermal converter producing a spontaneous flow of current as long as the temperature is maintained.

A possible thermal converter operating at ambient temperature is shown in figure 2. It differs from figure 1 in that its scale is now defined and the plates are coated with a thin layer of insulating material. One would think that this insulator would stop the electric charging process, but if the layer is thin enough then electrons can 'tunnel' through often enough to allow the converter to operate as intended. The main function of the insulator is to reduce the electric force holding the charged ball to the plate. Heat energy does not kick just the balls around, it also kicks electrons around. As a consequence of the thermal activation of electrons, the charge on the balls may be neutralised or even reversed. When the polarity of electric charges is reversed, we have an internal leakage current which can reduce or even stop the current in the external circuit. Fortunately, careful calculation shows that under certain conditions the cell can generate power.

If the cell generated any power at all, however little, it would mean that the second law is not a universal law after all, and that there probably exist other methods which also work and are of practical value. Fortunately, the thermal converter can generate enough power to be of very great practical interest. With development, it can only get better.

One such improvement is the suppression or elimination of the internal leakage current. Figure 3 shows a version of the converter in which the layers of insulating material are replaced with semiconductor material which can still perform the insulator's function. Plate A is coated with n-type semiconductor, and the balls can get electrons readily enough but can give up electrons only with great difficulty. The p-type semiconductor on plate B acts in reverse, and the cell now behaves like a diode with respect to the balls. Please note that the original analysis takes full account of the thermal activation of charges, and the claim that the converter works does not rely on this diode action.

Other improvements relate to the mass of the balls. By using hollow shells, their mass can be greatly reduced (we cannot make them smaller), which increases their speed and hence power output. The power of this device increases rapidly if the temperature at which heat is available is raised. Elevated temperature allows us to reduce the size and mass of the balls, and hence a larger number of balls per unit area move between more closely spaced plates at greater speed.

POTENTIAL APPLICATION OF THE THERMAL CONVERTER

A typical thermal converter would look like a stack of plates with air spaces between them. Air or water is drawn between the plates, keeping them warm. The power output is about one kW per kg of mass, and the average density is about 500 kg per cubic metre. This makes the converter powerful for its weight, and compact. For example, a 100 kW unit suitable for powering a car would have a weight of 100 kg and a volume of 0.2 cubic metres. The operation of the device is silent and vibration-free.

The converter could be used for both small- and large-scale power generation. If the electric power produced is expended in the locality of the converter, the environmental impact is very minimal because heat is taken from and returned to the environment at the same time. If the energy is exported to other places, as for example by electric transmission, then the environment of the converter is cooled.

It would be immediately useful in motor vehicles, ships, and industrial and domestic applications. For use in powering aircraft, a ratio of 10 kW per kg is desirable, and this application would need to await further development of the converter.

The converter is an intricate device requiring a high level of technology. A thousand cells might stack up to a thickness of

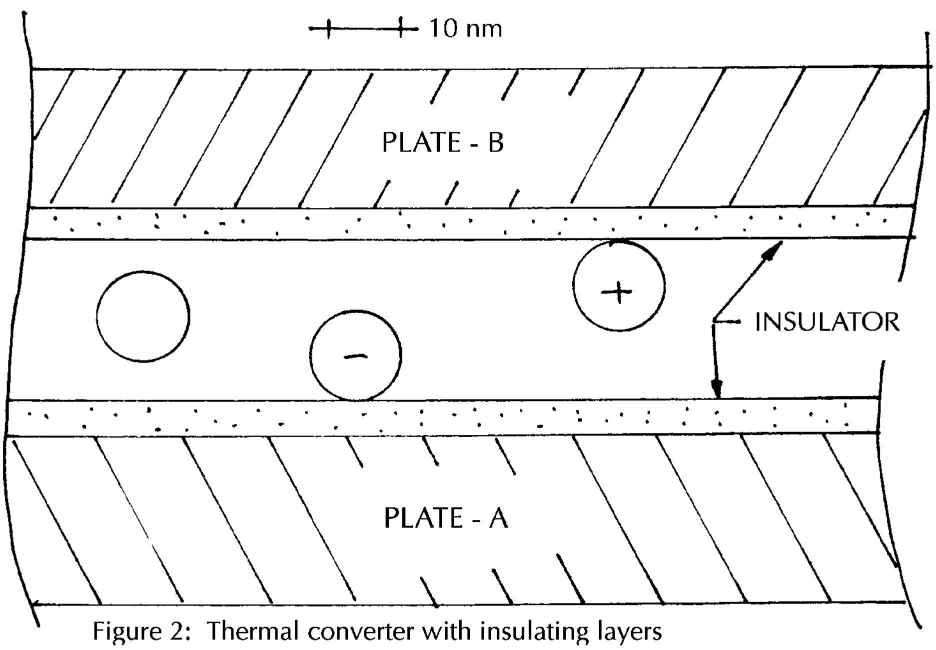

Figure 2: Thermal converter with insulating layers

one millimetre, and a typical unit might contain many thousands of cells. Initially their cost might compete with other power sources in only limited applications; and there would be an interval of perhaps a decade during which the converter could become competitive with power sources generally. This is the period during which foresighted government policies could smooth out dislocations that might arise.

When fully developed, the converter could be especially beneficial to economies and peoples whose energy costs are a large fraction of their cost of living. Its impact on economic and industrial activity would be in areas where energy is needed in large quantities. Fresh water is needed in large quantities, and the transport of water from places where it is available to where it is needed, or the conversion of sea water which is generally abundant around the planet, requires vast amounts of energy. The required energy is present in the water as heat, and can be taken directly from the water for the purpose of pumping and/or desalination.

The urgent need for mankind to learn to tread more softly as we manage and work with our ecosystem would create projects with a large energy component. Such things as de-polluting soils and waters, or the establishment of places of human habitation in the deserts, the oceans and underground where their environmental impact is less, would become feasible if a steady, reliable and sustainable source of energy were available.

The above comments apply equally to human habitats in space, on the Moon, Mars, Venus and Mercury, just as well as on Earth. Venus, in particular, is thought to be very hot. To survive in such an environment we need to keep heat out, and the converter is ideally suited for this. It is particularly sobering to realise that there is enough room, sunlight and material in our solar system to sustain habitats in space equivalent to several billions of Earths, and that every species of life we so wantonly destroy is actually billions of times more valuable as a vital component of these potential habitats than our Earth-oriented perspective can appreciate.

The perpetual recycling of heat energy, which this converter makes possible, is, on the physical side, what an unlimited bank account is on the economic side. In recent decades there has been much 'limited' thinking. To be sure, the planet and its resources are finite, but the creative resources which we can bring to it need not be limited. When a finite number is multiplied by an infinite number, the product is also infinite.

It is altogether unnecessary to sink into some kind of despondency about the future prospects of mankind on or off this planet. What we should do, and with the greatest urgency, is to stop and/or transform all those activities which have the effect of diminishing our planetary resources.

The second law has influenced philosophical thought more than most other natural laws in that it points to a kind of 'heat death' of the universe. The repealing of this law is therefore likely to remove or at least change these notions of 'universal mortality'.

In particular, since living cells operate roughly on the scale of the converter, one can envision bacteria and organisms which derive their energy requirements by thermal conversion. Such organisms would require neither food nor sunlight, and, provided they can obtain the necessary chemical substances to build and maintain their bodies, they can continue to exist in their environment indefinitely if it maintains a tolerable temperature range. From this perspective, almost every planet and many of the moons in our solar system have a thermal environment at some level of their structure that could be a habitat for life. ∞

Note: A larger version of this paper, which sets out a mathematical assessment of its viability, may be obtained from the author by return airmail for a fee of AUD$10.00. Send to Martin Gottschall, c/- PO Box 819, Mount Ommaney, Qld 4074, Australia. Enquiries, fax +61 (0)7 3376 1780.

About the Author:

Martin Gottschall, BE, ME, PhD, FDBA, is a consulting engineer. He has Bachelor's and Master's degrees in Mechanical Engineering and is a Doctor of Philosophy. His higher awards were by research in metal deformation and high-frequency friction respectively. He has always had a keen interest in many forms of energy generation including solar thermal and solar electric.

Figure 3: Using semiconductor layers to control charge polarity of balls